Overreaching on Ladders: Motivated to Succeed or Fail?

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Introduction

Falls from ladders remain a critical safety issue within the workplace due to the frequency at which falls occur and the severity of the resulting injuries. Guidelines for safe ladder use state that the body should remain within the rails of the ladder (“belly button” or “belt buckle” rule), yet, many ladder falls occur while workers are performing extended lateral reaches during task performance. Falls can occur because the individual loses balance and falls off the ladder or because the ladder tips over, causing the individual to fall with it.

Training regarding safe practices while using a ladder typically includes reaching guidelines, however, workers still overreach. Even with proper training, it is possible that workers will overreach due to other factors, motivations and influences. Workers may recognize the risk but determine that the additional risk is warranted to eliminate the time required to descend the ladder, reposition it, and ascend the ladder while performing a given task. The priority level given to safety, as dictated by coworkers and management, as compared to productivity will play an important role during this decision-making process. The relationship between overreaching and ladder falls must be emphasized during safety training. Practitioners at all levels need to better understand the ways in which workers are sometimes motivated to perform tasks unsafely. This paper will explore the effect of motivation (task completion) on lateral reach distances performed by experienced ladder users while working on stepladders of different heights.

Experiment

Participants
Participants in the study included 24 experienced male ladder users. The mean (sd) age, heights and weights were 47.8 (12.3) years, 173.6 (5.5) cm and 89.6 (12.1) kg, respectively. Participants had normal or corrected vision in both eyes and were free of known musculoskeletal and balance problems. Participants changed into sportswear and low-rise trail shoes (Nike Bandolier II) provided by the research team. A full body harness attached to a belay system was donned to...
maintain safety of the participants throughout the experiment. Motion capture markers were placed on the body to identify the location of body segments. Additional markers were placed on the ladders to identify the location of the rails and rungs relative to the body (e.g. reaching arm).

**Experimental Design**

Individuals were considered experienced users if they regularly climbed ladders as part of their employment (minimum tenure of 3 years). This study evaluated two fixed factors (ladder height and reach condition). Two ladder heights were included in the study (6’ and 12’) and two reach conditions were evaluated for each participant: initial maximum and motivated maximum. New Type 1A fiberglass stepladders of 6’ and 12’ were used during the experiment. Extra heavy-duty industrial ladders rated for up to 300 pounds (Type 1A) were chosen since they are most commonly used in commercial settings (e.g. construction sites).

Lateral reaches towards the right side of the ladder were performed while participants stood on the third rung from the top of the ladders. Figure 1 illustrates the experimental setup and a typical reach by one of the participants towards the target. For each ladder height, the order of which was randomly presented, participants initially performed a lateral reach with the instructions to “reach as far as you feel comfortable.” For the second trial the participant was asked to “reach as far as you can.” The initial maximum reach distance established by this trial was used to determine the lateral target locations used in the subsequent trials.

Participants were required to reach for, and press, a key from a computer keyboard (target), placed at a vertical height midway between the height of the acromion process of the right shoulder and right elbow. Participants were not allowed to lean on or brace against the target. The target was placed closer and farther to the ladder rail until a maximum motivated lateral reach distance was established (modified method of constant stimuli). The subsequent reach distance was presented without substantial delay when the participant was able to reach the target. If the participants were unable to reach the target at the current location, they were required to climb down from the ladder and perform a short (20 seconds) card-sorting task. In this manner, participants were motivated to reach for the target since the instructions implied that successful reaches would result in decreased time to complete the experiment. Participants were paid a flat rate for completion of the experiment so taking longer did not result in a financial benefit.
Dependent Variables
Reach distance (RD) was defined as the distance from the ladder rail to the right wrist in the frontal plane. The distance to the end of the hand was not used to determine reach distance so the technique used to push the target would not influence the distance measured. The first trial was considered as practice and not analyzed. The second trial at each ladder height was designated as the initial maximum reach. The maximum reach distance that resulted after the modified method of constant stimuli procedure was the motivated maximum distance. Additionally, the distance in the frontal plane from the participant’s belly button to the ladder rail was measured (BBD).

Experimental Results
The reach distances and belly button distances for the experimental conditions are presented in Table 1. A positive BBD value indicated that the participant allowed the belly button to pass beyond the side rail of the ladder. All participants had a positive BBD while reaching on the 6-foot ladder when motivated, and only one participant kept their belly button within the side rail for all trials while reaching on the 12-foot ladder. Reach distance and belly button distance were significantly shorter on the 12’ ladder as compared to the 6’ ladder ($p<0.001$). The initial maximum was always the shortest reach distance with significant increases for the motivated reach condition ($p<0.001$).
Ladder Height | Reach Condition | RD (mm) | BBD (mm)
---|---|---|---
6' | Initial | 936 (69) | 48 (49)
 | Motivated | 1040 (56) | 115 (38)
12' | Initial | 871 (72) | -6 (56)
 | Motivated | 999 (75) | 84 (53)

Table 1. Reach and belly button distances for each of the experimental conditions.

**Discussion**

Ladders are used on a regular basis on many types of job sites, including construction sites. Even though falls from ladders occur relatively frequently, workers continue to disregard safety guidelines by overreaching while on ladders, increasing fall risk. Workers’ behaviors may be influenced by many factors, including their individual level of risk perception, peer pressure and time constraints imposed by management. Individuals that associate working on ladders with a high level of fall risk may abide by safety guidelines and be less inclined to overreach, whereas those who prioritize speed of task completion may overreach in an attempt to increase productivity.

Anxiety attributed to being at heights has been shown to detrimentally affect postural control (Huffman et al., 2009; Davis et al. 2009) so it was not surprising that users would be less willing to reach further on a taller ladder. This was likely partially due to feelings of increased instability. The introduction of a concrete task and a time component had a significant effect on reaching distance. Individuals generally want to succeed at completing tasks efficiently and in a timely manner. This desire may alter an individual’s risk assessment of the situation, leading them to perform tasks that they deem unsafe in other circumstances. These feelings may be intensified in employees who are trying to impress their coworkers and managers. It is imperative that management and coworkers clearly articulate that safety is a priority on the jobsite.

Safety guidelines recommend that the belly button not move past the side rail of the ladder during reaching or working on the ladder in order to prevent overreaching and tipping of the ladder. Although most participants reached far enough, such that their belly button moved past the side rail of the ladder, reach and belly button distances were shorter on the taller ladder. These results may indicate a differing level of risk perception depending upon working height, but all work at elevations is potentially dangerous so individuals must be aware of the safety guidelines and be instructed to abide by them regardless of the working height. An individual’s assessment of risk is often inadequate/incorrect and may lead to unsafe behaviors.

Effects of the experimental variables on BBD were similar to those of RD, however, RD increased at a larger rate than BBD. Since the change in BBD and RD were not the same for the various experimental conditions, it is clear that the individuals are implementing different reaching techniques (i.e. altered body segment locations and angles) to achieve larger RD but keep the belly button (i.e. center of mass) closer to the ladder. This may indicate a desire to keep the body stable but increase RD by ‘straightening’ the body and becoming more horizontal. Some reaching techniques do not follow safe guidelines for ladder use (e.g., only maintaining two
points of contact with the ladder) and may increase the risk of the individual falling off the ladder, even if the ladder itself does not tip over.

Ladder specific safety training should provide continuous reinforcement regarding the prioritization of safety over task completion speed. The relationship between overreaching and ladder falls must be emphasized, possibly by recounting the history of injuries related to ladders on the jobsite. Practitioners at all levels should benefit from a greater understanding of how workers are sometimes motivated to perform tasks unsafely.

**Bibliography**
